JAMA Insights

Point-of-Care Ultrasound in Sepsis and Septic Shock

Timothy B. Kaselitz, MD, MPH; Christopher W. Seymour, MD, MSc

Point-of-care ultrasound (POCUS) is a portable imaging tool used to guide clinicians in the rapid assessment of patients at the bedside. Because POCUS is noninvasive, radiation sparing, inexpensive, and allows for repeat examinations with evolving clinical circumstances, its use has increased. POCUS is commonly used in emergency departments (EDs) and intensive care units (ICUs), and is now part of the Accreditation Council for Graduate Medical Education's core requirements for emergency and critical care medicine training programs in the US.[1,2]

Multimedia

Related article page 1688

CME at jamacmelookup.com

Several studies have demonstrated the feasibility of using POCUS in the care of patients with sepsis, including identification of an infectious source (eg, pneumonia, empyema, cholecystitis, endocarditis), aiding in common bedside procedures (eg, central venous catheter placement, arterial line placement, percutaneous drainage of body cavities), and guidance for intravenous (IV) fluid administration to avoid overresuscitation (eg, pulmonary edema).[2-4]

Performed at the bedside by emergency medicine physicians and intensivists, focused cardiac ultrasound (FoCUS) is a specific POCUS modality that uses a limited number of standard echocardiographic views (eg, parasternal long and short axis, subcostal, apical 4 chamber, and apical 5 chamber, which includes the left ventricular outflow tract [LVOT] as the "5th chamber") for rapid visualization of heart structures, evaluation of cardiac contractility, and assessment of intravascular volume. Compared with standard echocardiography, FoCUS is a more rapid and less comprehensive procedure, contributing information for rapid diagnosis and effective treatment of patients with sepsis and septic shock,[5,6] but should not be viewed as a replacement for standard echocardiography. FoCUS can help identify sepsis-induced cardiomyopathy, an acute, reversible decrease in myocardial function in patients with sepsis, which may require more restrictive fluid administration and/or addition of an inotrope compared with patients without this syndrome.[3,5,6]

Determination of Fluid Status With FoCUS

The 2016 Society of Critical Care Medicine (SCCM) guidelines provide a strong recommendation for the use of FoCUS in guiding fluid resuscitation in patients with septic shock.[6] Optimization of tissue perfusion and oxygenation is a critical step in managing septic shock, and can be accomplished by administering IV fluid boluses and vasoactive medications, which should be individualized to the specific needs of each patient.[7] One of the most useful applications of FoCUS is hemodynamic profiling—assessing cardiac preload, afterload, and contractility—to help provide an individualized treatment approach. Using these parameters, FoCUS predicts the hemodynamic response to volume expansion with an IV fluid bolus, commonly referred to as *volume responsiveness*.[5,6] For patients with refractory hypotension and hypoperfusion who are no longer volume responsive based on evaluation with FoCUS, clinicians can use therapies other than IV fluids, such as vasopressors and/or inotropes.[6]

How to Measure Volume Responsiveness With FoCUS

Until recently, the assessment of volume responsiveness was performed using static measurements, such as heart rate, central venous pressure, and pulmonary artery occlusion pressure. The 2021 Surviving Sepsis guidelines, using the GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) method, provided a weak recommendation preferring dynamic measurements, such as stroke volume variation, to predict volume responsiveness.[8] Stroke volume variation is the beat-to-beat change in stroke volume in response to a change in cardiac preload, and can be derived with FoCUS by measuring the variation in LVOT velocity time integral (VTI).[9] Using pulsed wave Doppler, the examiner measures the speed of blood flow through the LVOT over multiple cardiac cycles while applying a reversible change in preload.[9]

Preload can be changed during FoCUS by increasing tidal volumes to approximately 8 to 10 mL/kg in an intubated and sedated patient or by performing a passive leg raise in an intubated or nonintubated patient.[9] Administering a larger tidal volume induces a greater dynamic change in cardiac preload via a greater change in intrathoracic pressure throughout the respiratory cycle. A passive leg raise transfers approximately 300 mL of venous blood from the legs to the heart and is achieved by moving a patient from a 45-degree heads-up position to 45-degree legs-up position while the head is kept flat. Contraindications to passive leg raises include lower limb amputation, elevated intracranial pressure, and pain with performing the movement. With the passive leg raise method, the VTI should be calculated before and no more than 1 minute after performing the maneuver.

After performing these maneuvers, the waveforms generated by FoCUS are integrated over time by measuring the area under the curve of the maximum and minimum waves.[9] Clinicians have typically performed VTI calculations by tracing the waveforms by hand, although software on new machines can automate this process. A difference between VTI_{max} and VTI_{min} of 10% to 15% is consistent with fluid responsiveness, and a difference of less than 10% suggests withholding fluid administration.[9]

Evidence for POCUS and FoCUS

In the medical literature, the terms POCUS and FoCUS are frequently used interchangeably. Rigorous evidence supporting the use of this portable ultrasound imaging tool in sepsis and septic shock is increasing but remains limited because few randomized studies have been performed, and nonrandomized studies are limited by case mix, operator variability, and heterogeneity in outcomes.[10] A 2023 literature review of 26 studies concluded that

© 2025 American Medical Association. All rights reserved, including those for text and data mining, AI training, and similar technologies.

Downloaded from jamanetwork.com by guest on 05/28/2025

SHOUT
SHARE
IT

POCUS potentially aids in the rapid identification and effective treatment of sepsis and septic shock in the ED.[10] Among 9 studies examining the contribution of POCUS to the diagnosis of distributive shock among undifferentiated hypotensive patients, POCUS combined with clinical assessment had a sensitivity of 63.6% to 75%, a specificity of 99.7% to 100%, positive predictive value of 87.5% to 100%, and negative predictive value of 86.1% to 100%.[10] In a single-center randomized trial of 202 ED patients with septic shock, fluid resuscitation based on portable ultrasonographic assessment of the change in inferior vena cava diameter during respiration led to a 700 mL decrease in IV fluid administration at 6 hours compared with usual care, but there was no difference in all-cause 30-day mortality.

Practical Considerations and Limitations

Use of a portable ultrasound imaging tool in the evaluation and treatment of sepsis has some challenges. First, many conditions encountered in critically ill patients reduce the predictive ability of FoCUS dynamic measurements for assessing fluid responsiveness, including cardiac arrhythmias (eg, atrial fibrillation), structural heart disease (eg, hypertrophic cardiomyopathy), valvulopathies (eg, aortic stenosis), right ventricular dysfunction, poor lung compliance, intra-abdominal hypertension, and cardiac tamponade.[5,9] Second, because this imaging technique requires dedicated training and practice to learn and maintain, there may be substantial heterogeneity in experience and proficiency among clinicians. Third, mistaken interpretations and missed diagnoses can lead to incorrect assessments and treatment decisions. Fourth, because POCUS and FoCUS videos and images are discoverable from a medicolegal perspective, clinicians may be exposed to liability risk if medical errors or unintended consequences arise. In an effort to address these barriers, the SCCM published evidence-based guidelines for the use of bedside cardiac ultrasound, and there is now a formal certification process available for critical care echocardiography offered by the National Board of Echocardiography.[5,6]

Conclusions

POCUS is a portable, noninvasive, and radiation-sparing imaging modality that can aid in the diagnosis and treatment of patients in the ED and ICU. FoCUS, which provides a limited number of standard echocardiographic views, is a useful adjunctive tool in the assessment and treatment of critically ill patients with sepsis and septic shock.

ARTICLE INFORMATION

Author Affiliations: Department of Critical Care Medicine, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania (Kaselitz); Departments of Critical Care and Emergency Medicine, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania (Seymour).

Corresponding Author: Timothy B. Kaselitz, MD, MPH, Department of Critical Care Medicine, University of Pittsburgh School of Medicine, Alan Magee Scaife Hall, Ste 600, Pittsburgh, PA 15213 (kaselitzt@upmc.edu).

Published Online: March 17, 2025. doi:10.1001/jama.2025.1983

Conflict of Interest Disclosures: Dr Seymour reported receiving grants from the National Institutes of Health's National Institute of General Medical Sciences and National Heart, Lung, and Blood Institute; and personal fees from Inotrem, Beckman Coulter, and Edwards Lifesciences. No other disclosures were reported.

Disclaimer: Dr Seymour is an associate editor of *JAMA* but was not involved in any of the decisions regarding review of the manuscript or its acceptance.

Additional Contributions: The authors thank Nate Langer and the UPMC Media Relations Team for assistance with producing the video.

REFERENCES

1. Kassutto S, Baston C. Entrusting the process: assessment of critical care ultrasound skills in fellowship trainees. *ATS Sch*. 2023;4(1):8-11. doi:10.34197/ats-scholar.2023-0006ED

2. Polyzogopoulou E, Velliou M, Verras C, et al. Point-of-care ultrasound: a multimodal tool for the management of sepsis in the emergency department. *Medicina (Kaunas)*. 2023;59(6):1180. doi:10.3390/medicina59061180

3. Spampinato MD, Luppi F, Cristofaro E, et al. Diagnostic accuracy of point of care ultrasound (POCUS) in clinical practice: a retrospective, emergency department based study. *J Clin Ultrasound*. 2024;52(3):255-264. doi:10.1002/jcu.23619

4. Williams JP, Nathanson R, LoPresti CM, et al. Current use, training, and barriers in point-of-care ultrasound in hospital medicine: a national survey of VA hospitals. *J Hosp Med*. 2022;17(8):601-608. doi:10.1002/jhm.12911

5. Vieillard-Baron A, Millington SJ, Sanfilippo F, et al. A decade of progress in critical care echocardiography: a narrative review. *Intensive Care Med*. 2019;45(6):770-788. doi:10.1007/s00134-019-05604-2

6. Levitov A, Frankel HL, Blaivas M, et al. Guidelines for the appropriate use of bedside general and cardiac ultrasonography in the evaluation of critically ill patients—part II: cardiac ultrasonography. *Crit Care Med*. 2016;44(6):1206-1227. doi:10.1097/CCM.0000000000001847

7. Boyd JH, Forbes J, Nakada TA, Walley KR, Russell JA. Fluid resuscitation in septic shock: a positive fluid balance and elevated central venous pressure are associated with increased mortality. *Crit Care Med*. 2011;39(2):259-265. doi:10.1097/CCM.0b013e3181feeb15

8. Evans L, Rhodes A, Alhazzani W, et al. Surviving Sepsis Campaign: international guidelines for management of sepsis and septic shock 2021. *Intensive Care Med*. 2021;47(11):1181-1247. doi:10.1007/s00134-021-06506-y

9. Wang J, Zhou D, Gao Y, Wu Z, Wang X, Lv C. Effect of VTILVOT variation rate on the assessment of fluid responsiveness in septic shock patients. *Medicine (Baltimore)*. 2020;99(47):e22702. doi:10.1097/MD.0000000000022702

10. Verras C, Ventoulis I, Bezati S, Matsiras D, Parissis J, Polyzogopoulou E. Point of care ultrasonography for the septic patient in the emergency department: a literature review. *J Clin Med*. 2023;12(3):1105. doi:10.3390/jcm12031105

© 2025 American Medical Association. All rights reserved, including those for text and data mining, AI training, and similar technologies.

Downloaded from jamanetwork.com by guest on 05/28/2025